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ABSTRACT

America is shifting from an industrial age to a technological age, and educational observers are questioning the ability of our nation's schools to prepare its youth to deal with the changing nature of their country. With studies showing declining abilities among high school graduates in math competency, reading skills, and inferential reasoning and persuasive writing, schools have embraced new technologies as cures for their ills. Traditionally conservative institutions have acquired microcomputer technologies faster than they can learn how, when, or where to use them. Despite the large number of computers that have entered the nation's schools, the development and application of information technology has lagged behind due to several institutional and societal barriers: (1) inherent difficulties when institutions attempt to adapt curricula, schedules, and classroom organizations; (2) apathy or overt hostility on the part of some teachers toward computers and computer instruction; (3) difficulties with teacher training in the use of technology and in the production and selection of effective curriculum materials; and (4) a lack of adequate software. Educational leaders must stop and reflect on their future mission, develop goals and strategies for attaining that mission, assess their progress, and reevaluate their mission and strategies in light of this assessment. (THC)

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MICROCOMPUTERS IN EDUCATION:

TOO MUCH TOO SOON

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Computers as Schools' Response to a Society in Flux

America is in the throes of shifting from an industrial age dependent on physical labor to a technological age which is brain intensive and dependent on knowledge. In 1950 only 17 percent of the labor force was in information jobs compared with over 60 percent today. Conversely, only 13 percent of the labor force is involved in manufacturing operations (31). Drucker predicts that the next quarter century "is likely to require innovation and technological change as great as any we have ever witnessed" (13, p. 46). This transformation is creating a society whose economic, political, and social structures are still unclear and which, therefore, lacks stability. Further, the change is occurring in a no-growth society characterized by inflation, unemployment, urban decay, and a dramatic decline in the standard of living. National problems are compounded by those of the world-at-large. Wars continue in the Middle East and Central America. Problems of world-wide hunger and poverty, environmental rape and pollution, and discrimination and prejudice appear insoluble.

Increasingly educational observers have come to question the ability of our nation's schools to prepare its youth to deal with these world-wide problems and with the changing face of our own country. Data indicate that a large number of high school graduates face the world as near-illiterates. Among recent high school graduates entering New Jersey state colleges in 1982, for instance, 39 percent could not demonstrate competence in sixth grade math (4).

Remedial courses in college are commonplace with math enrollment climbing 70 percent between 1975 and 1980 (4). Studies show declines in inferential reasoning and persuasive writing as well (4). In general, students in the United States have been found to suffer in comparison with those in other industrialized nations. A spate of national reports all present the current state of education as in severe crisis. Although we are normally an optimistic country with a belief that national resolve can conquer any problem, for the first time in our history, there is a prevalent belief that the public schools will not "make it." Sarason notes, "There are limits to national optimism and, according to some people, the schools have exceeded them" (40, p. 38).

In this negativistic climate, schools have avidly embraced the new technologies as a panacea for their ills. Traditionally conservative institutions, they have acquired the technologies faster than they can learn how, when or where to use them. Watt observes that "schools are in the grip of a computer mania" (47, p. 83), with the influx of microcomputers growing from a trickle to a torrent. Data from the National Center for Education Statistics indicate there were approximately 31,000 microcomputers in the schools in the fall of 1980 and 96,000 by the spring of 1982. Market Data Retrieval of Westport, Connecticut, estimates there are currently 325,000 microcomputers in the schools and 720,000 are projected by year-end. By 1985, the Houston Independent School System alone plans to have 30,000 microcomputers in use and 95 percent of all students in Minnesota are

believed to have access to instructional computing services through MECC (31).

Schools rushed headlong into the computer age for many reasons, not the least of which was strong parental pressure. It is predicted that by 1987, approximately 70 percent of the projected $1 billion market in educational hardware and software will be products for the home rather than for schools (47). Barraged by media hype, parents have come to believe that their children's future school and career success are largely dependent on their keeping up with technology. On the surface, their concern seems reasonable. They read that "computers will permeate the whole world of work" (31, p. 37), that "the new microelectronic age is radically changing the workplace" (42, p. 126), and that as early as 1985, 75 percent of all jobs will involve computers in some way (9, p. 88). They also read that the job market is changing with existing jobs (e.g., postal workers, elevator operators, farm laborers) and industries (e.g., manufacturing, steel) dying out and new jobs (e.g., energy technicians, housing rehabilitation technicians, holograph inspection specialists) and industries (e.g., information processing and telecommunications, aerospace, biotechnology) emerging (6). At the same time, they read the national reports that criticize the schools' abilities to teach mathematics, science and computer science (32), that businesses are having to compensate for the illiteracy of high school graduates (31), and that schools are continuing to turn out factory-style workers for jobs that won't exist (45). The demands of the future techno-

logical work place, contrasted with schools' apparent inability to prepare students to meet those demands, have made parents anxious.

But the statements regarding technology and the future rest on two assumptions: (1) that the labor market of the future will demand technological skills requiring considerable education and sophisticated training; and, (2) that the new technologies will demand more complex skills because workers will be involved with technologically sophisticated equipment, such as computers. Both of these assumptions are faulty. The first assumption comes from misreading the occupational predictions developed by the Bureau of Labor Statistics wherein percents are confused with numbers (3). While the fastest growing job categories may well be in high tech occupations, the number needed in that category relative to other categories is very small. High technology occupations are actually expected to account for only 7 percent of all new jobs between 1980 and 1990 (3). In fact, it is the lowest skilled jobs that are expected to outstrip growth in high technology jobs (27). Most job vacancies are expected to be for traditional workers (e.g., secretaries, nurse's aides and orderlies, janitors and sextons, sales clerks, cashiers, nurses, truck drivers, food service workers, clerks, waiters and waitresses, and elementary school teachers) and not technology workers (3). Bernstein suggests that this list consists exclusively of service occupations and is at odds with predictions that 60 to 70 percent of all workers will be employed in high technology work in the future. He feels the discrepancy is due to a misreading of "in" high technology work, when what is meant is that workers will use

high technology equipment (3). The fast food worker and supermarket cashier, for example, use computerized machinery but are clearly not working in high technology fields. The belief that considerable education and sophisticated training will be necessary is unfounded as well since only two of the occupations on the list of jobs with expected vacancies (i.e., nurse and teacher) require a college degree.

The second assumption, that the new technologies will demand more complex skills, is insupportable as well. "The proliferation of high technology industries and their products is far more likely to reduce the skill requirements of jobs in the U.S. economy than upgrade them" (27, p. 2). "User friendly" technology has already had the effect of downgrading the technical knowledge needed for many jobs. The new generation of office computers, for example, are designed so that "no specific skills are needed to operate" them (19, p. 149). Although equipment is becoming more sophisticated, it does not necessarily require more sophisticated skill on the part of the worker. In fact, evidence suggests that despite increased automation, the aggregate skill requirements of jobs has changed very little in the past two decades (38).

Judging by the recommendations of most of the national reports, it is assumed that increased training in mathematics, science, computers and technical applications is necessary for virtually everyone. However, if the two assumptions discussed above, in fact, are faulty, then in yielding to the external pressures of national reports and parents, educators will be transforming the educational system to meet non-existant needs and will be diverting scarce educational resources into

expensive equipment and training that will rapidly become obsolete.

Barriers to Computer Implementation

In spite of the large number of computers that have entered the nation's schools and the perceived benefits of computers, the development and application of information technology has lagged behind in the public schools. Thus, in 1980, the Office of Technology Assessment (OTA) was asked to reexamine the potential role of new information in education. The organization's results indicate that there are several institutional and societal barriers preventing the realization of the benefits of the educational technologies (35).

One barrier emanates from the institution itself which is being called upon to adapt curricula, schedules, and classroom organizations. Although OTA writes that "the changes are not likely to be extreme" (35, p. 19), others disagree. Decker Walker of Stanford, for example, believes "the only thing that is absolutely clear is that the introduction of computers will require changes in the day-to-day operation of classrooms" (46, p. 106). It is surprising, in fact, that OTA has down-played the difficulties inherent in the change. The organization acknowledges that a primary reason computer-assisted instruction failed in the late 1960s was a failure to integrate computer-based teaching methods into the institutional structure of the school. It also recognizes that "information technologies can be most effectively applied to educational tasks when they are well integrated in their institutional environments" (italics theirs) (35, p. 17). Yet most schools are finding such integration extremely difficult given a series of barriers

to computer implementation and given that we still do not know much about the educational and psychological effects of technological approaches to instruction. If OTA and others view implementation of technology into the curriculum as the sine qua non for effective use of technology in education, then education's past failures and the continued absence of institutional know-how present a significant barrier to change.

A second barrier concerns apathy or overt hostility on the part of some teachers toward computers and computer instruction. Deck notes that "while there is no consensus on the reactions of teachers to the advent of computer technology in schools, it is generally believed that teachers are suspicious and skeptical of school computer use" (10, p. 25). Some see computers as threatening to job security, individual freedom, and the rewards and conditions of work. Others see them as disrupting established classroom routines and creating new pressures on top of many already existing ones. Most teachers currently in the system were not raised in the electronic era and many are uncomfortable with anything "mechanical." While few are pure "technophobics," many have strong negative affect toward computers owing to their association with mathematics and science which also arouse negative affect. One study showed that 85.5 percent of the teachers responding agreed that "computers are valuable tools that can be used to improve the quality of education" and 81.4 percent agreed that teachers should know how to use computers in their classrooms," but only 66.2 percent agreed with the statement,

"I would like to have a computer for use in my classroom." The researcher concluded that educators seem "to be positive toward computers as long as the function of computers is removed from their experiential world of practice" (34, p. 132).

Another barrier concerns teacher training in the use of technology and in the production and selection of effective curriculum materials. OTA found too few teachers qualified in these areas and too few teacher training institutions providing adequate instruction to new teachers in the use of information technology. One survey of over 130 teachers in educational institutions in the southeast states, for example, indicated that less than one-half of them offer any kind of in-service training on microcomputers for faculty. Fifteen percent of responding institutions said they offered at least one specific course for pre-service teachers to acquaint them with the use of microcomputers for instruction and/or management in the classroom. Twenty-three percent of the institutions indicated they had such an inservice course of teachers. The survey findings underscored the fact that there is very little training in microcomputers available to practicing teachers or to those majoring in education in preparation for teaching (10). David Moursand estimates as few as 5 percent of the approximately 1350 teacher training programs in the U.S. offer undergraduate courses in computer education and only a small fraction of those now include such courses in their degree requirements (10). As a consequence, in a national survey, 92 percent of the teachers responding thought their students should attain computer literacy,

but 94 percent of the teachers did not feel adequately equipped to help students reach that goal (14).

Among the reasons that teacher training programs are slow to respond to the technological revolution are declining enrollments, budget cuts, an inability to identify qualified computer instructors, and "the realization that it takes a tremendous effort and commitment of time to learn the technology well enough to teach on a college level" (10, p. 25). While each generation of computers has become more "user friendly," computers, computer languages and even computer software take time to master, are intimidating to many and infuriating to nearly everyone. Rapid change and the lack of standardization among products compounds an already difficult training agenda. Dirr and Pedone note that generally "the new is more versatile than the old, is technologically incompatible with the old in one or several aspects, and represents new profiles or mixtures of costs and benefits" (12, p. 1200). Schools do not have the resources to provide continuous in-service training for ever-changing technology, nor will teachers indefinitely volunteer their spare time to retool.

The need for teacher training and its potential as a barrier to the successful implementation of technology in the schools cannot be underestimated. If one accepts, for example, that a primary advantage of computers is their potential for individualizing instruction, then the fact that most teachers are traditionally trained to deliver content in a group setting presents a serious problem. Research indicates that two-thirds of all classroom time is spent with teachers

talking and children listening (46). Clearly teachers are most comfortable in a didactic situation in the role of information-provider. They have neither learned nor been trained in the kind of thinking and problem-solving skills required to use computers as tools (23). But the instructional design methodologies and procedures suited to interactive instruction are very different from those used with passive media. It will take years to alter teacher training and to implement the needed changes among teachers already in the schools. We need to learn a lesson from the failure of computer-assisted instruction two decades ago: "What teachers seemed to define as teaching was capturing the attention of students and serving as a mediator between the student and the information. Since programmed instruction didn't seem to let them do that, it wasn't teaching and they circumvented the process" (5, p. 847). Thus, a strong barrier to successful implementation of technology in schools is teacher attitudes and a redefinition of what constitutes the teaching/learning process, both components of teacher training programs.

A fourth barrier concerns the lack of adequate software. While one problem is too many programs from too many sources, paradoxically, another problem is the limited range of choice. Approximately 90 percent of the programs reviewed for the education market are based on instructional drill and practice format with most software providing computerized versions of traditional methods (26). This emphasis on drill-and-practice reinforces the

use of computers as transmitters of predefined content and places the student in the role of receiver or respondent. While computers have the potential to create simulations that can teach high level thinking and problem solving, most software is aimed at teaching skills or draws almost exclusively on recall rather than developing higher order thinking. Further, programs are frequently "boring and pedagogically flawed" (21), rarely drawing upon established educational psychological principles such as advanced organizers, intermittent reinforcement, or feedback as to why the answer is incorrect rather than merely presenting the correct answer.

While the emphasis in computer technology to date has been on hardware, the future success of computers, particularly in schools, hinges on software and the degree to which teachers are able to incorporate it into their classrooms. Komoski, founder of E.P.I.E., looks back to the failures of past media and notes that schools took advantage of available federal monies to purchase products they did not know how to use, when to use them or why they were needed. All of the teaching tools that were heralded as ways to help teachers personalize instruction and improve the curriculum ended up in closets gathering dust because nobody knew enough to make the manufacturers of educational products make those products fit the needs of the teacher in the classroom. Thus, Komoski believes the current software situation will not improve until publishers are held accountable for their materials (24).

Finally, an ever-present barrier to the successful implementation of technology in the schools concerns cost. Although the cost of computer hardware and communication services has dropped dramatically over the past decade, investment in technology still represents a substantial commitment by schools already financially over-burdened. Further expense is incurred for updating equipment that changes at a rapid rate, for service contracts, for software (whose costs are still high), and for staff training. Each of these constitutes on-going annual expense.

History Repeats Itself

Over the centuries, teachers have had tools at their disposal to enhance the teaching-learning process. As with computers today, in each instance, the new medium was looked to as a panacea for the educational ills of the day, which, when cured, would have a beneficial effect on society. The radio and motion picture, for example, ushered in a new century while instructional television came on the scene in the 1950s and was looked to as a means of educating a post-war society. Teaching machines and programmed instruction followed on the heels of Sputnik and were expected to close the gap between the United States and Russia in the areas of mathematics and science.

As with computers, the introduction of each medium in the past has been accompanied by exaggerated claims for its benefits and for its potential to revolutionize education. Enthusiastic about the educational possibilities of motion pictures, for example, Thomas Edison believed that textbooks as the principle medium of teaching would be obsolete

and that it would be possible to teach every branch of human knowledge with the motion picture (39). Later, educators predicted that instructional television would carry some part of the teaching of the great majority of school children, while teaching machines were viewed as "really doing something about individual differences in education" and, therefore, having "potentially revolutionary significance, not only for the efficiency of instruction, but for the organization of classes and schools" (28, p. 592). They were touted as allowing for individual pacing and self-management by the student, for more effective use of teacher time, and for greater specificity of achievement standards (15,

While earlier media were viewed as panacea and introduced with critical acclaim, like computers, they, too, faced barriers to their implementation. In the late 1960s, programmed instruction, for example, received generous federal funding, but interest waned due to the high costs of hardware and curricula, and the failure to inegrate computer-based teaching methods into the institutional structure of the school (35). Motion pictures, overhead projectors, and teaching machines frequently were not even tried by teachers who were put off by anything mechanical. As is the case today, earlier barriers included institutional rigidities, problems with implementation, excessive cost, inadequate peripheral equipment, resistance by teachers, and skepticism regarding the long term effects.

What history has demonstrated is that, in spite of grandiose claims and early enthusiasm, each medium of instruction has essentially been forgotten, leaving education and the process of schooling virtually unchanged for nearly a century. Despite Edison's optimism, films are today an insignificant instructional aid. There is not even a readily available count of the number of educational films used in schools or colleges, number of showings, or number of pupil hours of film viewing a year (28). With regard to the radio, instructional programming constitutes only 1.2 percent of the hours broadcast for grades K-12 and less for other categories (22). Instructional television has also proved a disappointment. Between 1977 and 1980, educational expenditures in support of ITV averaged $3.27 per student per year. This was only .025 percent of the total education budget for that period (18). Further, evaluation of the effectiveness of television as an instructional tool has shown that television for a complete course is inferior to classroom lectures in communicating information, developing critical thinking, changing attitudes, and arousing interest (29). Teaching machines and programmed instruction, although grounded in scientific principles of learning (43, 44), have also had minimal impact (15). Evaluations by the Educational Testing Service of PLATO (30) and TICCIT (1), two programs on which the federal government spent $14 million during the 1960s, were not encouraging and a recent meta-analysis of 59 independent evaluations showed computer-based instruction at the college level made small but significant contributions to the course

achievement of college students, but with an effect size equal to only one quarter of a standard deviation (25) - hardly revolutionary!

In summing up the impact of media on learning, Clark concluded, "Five decades of research suggest that there are no learning benefits to be gained from employing different media in instruction, regardless of their obviously attractive feature or advertised superiority. All existing surveys of this research indicate that confounding has contributed to the studies attributing learning benefits to one medium over another and that the great majority of these comparison studies clearly indicate no significant differences" (8, p. 450). Baker similarly concluded that technological breakthroughs have not produced consequences which have seriously affected educational practice (2).

Implications for Computers in the Schools

History's message seems to suggest that enthusiasm and hype are insufficient to sustain a medium of instruction. In fact, promises not met and expectations unfulfilled often produce strong negative affect. It is already becoming clear that microcomputers have been oversold too early creating a mounting backlash and opposition to the campaign for computer literacy in the schools (41). Dieuzeide, reflecting on the uses of media as "palliatives and stop gaps which are used as a remedy for inherent deficiencies in the educational system," rejected the notion that technology can be expected to resolve the crises in education (11, p. 7). Within the last year, this perception has grown as educators confront the limitations

inherent in computer technology. Computers "seduced" parents and educators so instantaneously and completely that they prematurely committed funds for equipment and facilities, frequently failing to include in the planning those people who would be involved in the technology, frequently failing to determine whether appropriate program materials were available, and frequently failing to be objective about the limitations of the new idea (37). It is not surprising that when we expect too much from a new idea and overstate its value, we will be disappointed. Nor is it surprising that when we grasp at a new idea and attempt to implement it without sufficient planning, it should fail.

Most innovations throughout history were introduced with the hope that they would become a major agent for educational change. So too the microcomputer. But its effectiveness rests heavily upon our ability to perceive its role and nature clearly. This suggests the need for thoughtful, careful and thorough research prior to implementation. Sylvia Charp, Editor of T.H.E. Journal, argues that technological advances occur so fast, we don't have the luxury of research and development (7). In fact, we don't have the luxury not to slow down and invest time and effort in research. The recent explosion of the programming language, Logo, throughout the schools is a case in point. Developed over seventeen years ago at M.I.T., Logo has grown in use at an astronomical rate. During the year 1982 alone, the use of Logo in schools jumped from less than a dozen sites to hundreds, and it was expected to involve thousands of classrooms with tens of thousands of students within the following year (48).

As a language, Logo is structurally superior to BASIC and has the seeming additional benefit of being comprehensible to children as young as three or four years of age (20). But Logo's appeal lies not as much in its programming capabilities as in the claim that it is a language for learning how to think. Its proponents believe that along with introducing the concepts for programming, Logo promotes metacognitive skills like planning and problem solving (36). The excitement Logo has generated, then, comes not so much from a perceived value of learning to program per se, but from a belief that through learning to program in Logo, children's cognitive capacities will be greatly expanded and they will develop higher level cognitive skills which will generalize or transfer to other content areas.

Unfortunately, theory does not support such a belief in an all-purpose problem solver with generalized transfer capabilities (17, 33). Credability for Logo and its proposed role as a mechanism for enhancing problem-solving ability must thus come from empirical support. However, few schools awaited empirical evidence before introducing Logo and, in truth, there was little to be found. Two large early Logo projects (one at the Lamplighter School in Dallas, Texas and the other in the Brookline, Massachusetts schools) produced little or no research regarding Logo and problem solving (48). It was not until 1983 that strong empirical evidence was produced. Results repeated by Bank Street College's Center for Children and Technology, "raise serios doubts about the claims made for the cognitive benefits of learning to program, particularly in Logo" (30). Cognitive gains

expectable from programming's organizational opportunities and demands do not show up or carry over to planning abilities, nor, to go even further, are the organizational possibilities within programming themselves exploited (16). Surely it would have been more pedagogically sound and cost effective to await such empirical results before embracing this programming language.

Many claims have been made for microcomputers, but few of these claims have been put to the test. While schools have an obligation to prepare children for a technological society, how that can be accomplished most effectively is still unknown. What is clear, however, is that it will take considerable thought and planning, cautious implementation, and on-going evaluation. Education cannot afford merely to innovate for innovation's sake. There must be a master plan designed and executed by thoughtful leaders who can anticipate the future and who are capable of developing strategies to restructure the educational system to meet that future. The industrial age is over and with it has gone the need for schools to emulate the centralized and hierarchical structure of the factory. The newly emerging information age demands a decentralized and lateral structure, one which is facilitated by the new technologies. To enter the new era, the teaching role will need to be redefined and new instructional techniques developed, with primary attention being paid to the fact that the student needs to be responsible for his/her own learning. With the rapid proliferation of information, the traditional notion of content mastery and the pedagogical emphasis

on fact and recall are no longer tenable. Educational leaders need to stop and reflect on their future mission, to develop goals and strategies for attaining that mission, to assess their progress, and to reevaluate their mission and strategies in light of their assessment. Glaser suggests that a lesson that needs to be learned is that a careful balance must be maintained between educational research and development with the interaction between theory and development being carefully preserved (15). At all times, educators must <u>first</u> know where they are headed. Only then are they ready to act.

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